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Clean water supply vulnerability model for improving the quality of public health (environmental health perspective): A case in Spermonde islands, Makassar Indonesia

Agus Bintara Birawida[a,*], Erniwati Ibrahim[a], Anwar Mallongi[a], Alif Alliullah Al Rasyidi[b], Yahya Thamrin[c], Nurul Aqilah Gunawan[d]

[a] Environmental Health Department, Faculty of Public Health, Hasanuddin University, Indonesia
[b] Environmental Health Department, Health Polytechnic of Ujung Pandang, Indonesia
[c] Occupational Safety and Health Department, Faculty of Public Health, Hasanuddin University, Indonesia
[d] Computer Laboratory, Faculty of Public Health, Hasanuddin University, Indonesia

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ABSTRACT

Objective: This study aims to generate a clean water vulnerability model based on exogenous variables: accessibility, socio-economic, and population behavior to endogenous variables: occupancy density and water vulnerability to support the quality of public health in Spermonde island.
Methods: This research was conducted in three islands (Spermonde), namely Lae-Lae, Barang Caddi, and Lumu-Lumu. The research design is observational analytic with a cross-sectional approach. The 212 respondents were obtained using a simple random sampling method. A questionnaire was employed to interview respondents related to the level of environmental vulnerability. Data were analyzed using structural equation modeling (SEM).
Results: The study found some variables are not statistically significant associated with water vulnerability such as accessibility to occupancy density ($P = 0.095$), socio-economic to occupancy density ($P = 0.991$), accessibility to water vulnerability ($P = 0.383$), socio-economic against water vulnerability ($P = 0.417$), occupancy density for water vulnerability ($P < 0.01$). In contrast, behavior to occupancy density ($P = 0.002$), behavior towards water vulnerability ($P =$ below 0.01) have a significant association.
Conclusion: Community behavior and occupancy density are the main factors associated with the vulnerability of clean water on the small spermonde islands. Adaptation behavior with water vulnerability such as water storage and saving needs to be improved.

Introduction

Isolation and low economy cause poor quality of life on the island. Low productivity is the determination of the low economy to sustain people's lives.[1] This condition illustrates the high vulnerability of people who are living in small islands.

The various problems are interrelated in the Spermonde islands. Economic problems affect the health factors of coastal and island communities, including basic hygiene, availability of clean water, and limited food. Pollution can occur in water, based on the calculation of the Water Quality Index (WQI), as many as 14 out of 18 well water is polluted.[2] Other than that, bad behavior in food and beverage management can worsen the quality.[3] Sanitation behavior also influences the water crisis, such as how to taking and using water.

Small islands with all their problems are not only environmental problems. Ecologically, small islands are fragile and vulnerable. Small size, limited land, limited resources, geographical distribution, and isolation from the market, making small islands vulnerable. The vulnerability received the attention of the Small Island Development State (SIDS) countries. Island communities tend to have water sources that do not meet the requirements and the inability to maintain cleanliness. This makes the island an area that is vulnerable to diseases and deaths due to sanitation-related diseases.[4]

Low availability of clean water can be a risk factor for several diseases that often occur, ranging from ordinary stomach aches, diarrhea, typhus, intestinal worms, dysentery, to urinary tract infections. This is like what happened in the Spermonde Islands in the Makassar City area. Lae-Lae Puskesmas diarrhea data in 2016 amounted to 48 and increased in 2017 to 55 cases and 2018 in January as many as 7 cases. Barrang Caddi Health officer data in 2017 with 96 cases. At the same time, the data in Lumu-Lumu diarrhea became the seventh-ranked disease that often suffered by people in 2017, with 266 cases.

Small island ecosystems also have limited carrying capacity of both land and clean water. Some small islands have a fairly large population density. Population density on small islands will cause pressure on the environment and have an impact on decreasing

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* Corresponding author.
E-mail addresses: agusbirawida@gmail.com, pmc@agri.unhas.ac.id (A.B. Birawida).

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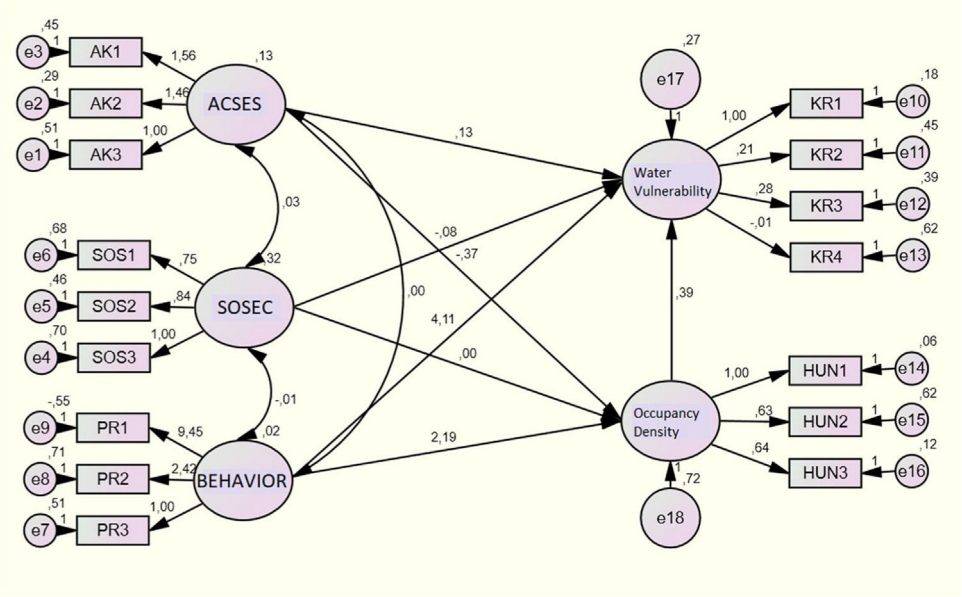

Fig. 1. Model of accessibility, socio-economic, and population behavior to endogenous variables: occupancy density and water vulnerability on the Spermonde island.

island resources, for example, the availability of clean water, which is increasingly scarce. One study conducted on the Malaysian island of Kapas showed an increase in foreign and local tourist arrivals, increasing the level of water demand.[5]

The vulnerability assessment of small islands is part of the sustainable management of the islands. Therefore this research was conducted to develop a model of a clean water vulnerability based on Exogenous variables: Accessibility, Socio-Economic, and Population Behavior to Endogenous variables: occupancy density and water vulnerability on the spermonde island.

Method

Level of environmental vulnerability

Some indicators are included in the assessment of the level of environmental vulnerability with the analysis of the Structure Equation Modeling (SEM). Exogenous variables comprise accessibility, behavior, and social economy. Endogenous variables are divided into occupancy density and water vulnerability.

Subjects

A total of 212 samples was collected in the spermonde islands around Makassar City using a simple random sampling method. There were three islands included in this study, namely Lae-Lae totaling 86 houses, Barrang Caddi totaling 77 houses, and Lumu-Lumu totaling 49 houses.

The minimum sample size needed is determined by the Lemeshow formula:

$$n = \frac{Z^2_{1\frac{\alpha}{2}m} \cdot P(1-P)N}{d^2(N-1) + Z^2_{1\frac{\alpha}{2}m} \cdot P(1-P)}$$

Information:
n = volume of sample
N = volume of population
d = level of desired absolute accuracy
$Z^2_{1-\frac{\alpha}{2}m}$ = level of the desired meaning
P = proportion estimate

Table 1
Evaluation of measurement for the entire model.

Model measurer	Criteria 'fit'	Result	Evaluation of model
RMSEA	≤0.08	0.077	Fit
GFI	>0.90	0.882	Marginal fit
AGFI	>0.90	0.829	Marginal fit
RMR	<0.08	0.049	Fit
CFI	>0.90	0.877	Marginal fit
NFI	>0.90	0.804	Marginal fit
IFI	>0.90	0.880	Marginal Fit
RFI	>0.90	0.750	Marginal fit

Research design

This research is a quantitative study using observational analytic design with a cross-sectional approach that aims to develop a model of factors that affect water vulnerability on the small Spermonde islands.

Data collection

Data was collected by researchers using a questionnaire. Instrument validation was tested with the Pearson product-moment correlation technique. While the reliability of the instrument was tested using Alpha Cronbach. Data were analyzed using SEM analysis with the Amos program 18.

Result

The estimated values of water vulnerability can be described in Fig. 1.

The model test results that are presented in Fig. 1 above are evaluated based on the goodness of fit indices in Table 1 by presenting the model criteria as well as the critical values that have data suitability.

From the evaluation of the proposed model, it can be seen that the evaluation of the construct of two variables produces values below the fit criteria, meaning that the model is by following per under the data so that the next model suitability test can be performed. The complete measurement model for water vulnerability

Table 2
Evaluation of the coefficient of the structural model and relation with the research hypothesis.

Hypothesis (path)	Evaluation of model direct effect		
	Fakor loading (estimate)	*p*-value	Conclusion
Occupancy density ← accessibility	0.365	0.095	Not significant
Occupancy density ← social economy	0.002	0.991	Not significant
Occupancy density ← behavior	2.193	0.002	Significant
Water vulnerability ← accessibility	0.128	0.383	Not significant
Water vulnerability ← social economy	0.081	0.417	Not significant
Water vulnerability ← behavior	4.105	<0.01	Significant
Water vulnerability ← occupancy density	0.338	<0.01	Significant

has shown that there is a fit model that matches the data with the model (Table 1).

Referring to the principle of Parsimony Theory, the model above shows a good level of acceptance. Therefore it implies that the model can be accepted and developed further. Based on the empiric model proposed in this study, testing of hypotheses can be carried out through the path coefficient on the structural equation model. If the *p*-value is smaller than 0.05, then the relationship between variables is significant. The test results are presented in the following Table 2:

Table 2 depicts that this study found a relationship between behavior with occupancy density, behavior with water vulnerability, and occupancy density with water vulnerability.

Discussion

About 43% of the respondents were far away from clean water access and facilities. This condition had an impact on the vulnerability of clean water. In Tanzania, access to clean water has greatly affected the well-being of the Tanzanian community.[6] Utilization of tap/pipe water and group water management are the best solutions in the provision of clean water in Tanzania.[6]

In contrast to the results of the research with SEM analysis models where the level of community access on the Spermonde islands to clean water is not significant. This happens because the community is not too constrained by access to resources. The community can go to the source of clean water to traders on each island by private transportation. The same results the accessibility to occupancy density are unrelated. This is caused because residents who have long lived on the island for generations have more initiative to develop by leaving their island.

The socio-economic level of clean water vulnerability is not significant. Even though the community has a low income, they prioritize buying water over other goods. The water scarcity on the small island requires them to buy water at a high price. The water scarcity on a small island has occurred 70 years ago and is still ongoing.[7] The same results suggest that socioeconomic factors are insignificant in residential densities.[8] This is because people who live for generations on the island, move from the island to the mainland with the path of urbanization. They are urbanizing because they want to get a better income. In contrast to communities in the Philippines, they have more choice to remain on the island than relocation to the mainland.[8]

This study also highlights that community behavior has a significant effect on water vulnerability. This is due to the high response in dealing with water vulnerability. People choose to save money in water use. Also, they harvest rainwater harvesting. The influence of community behavior on occupancy density was statistically significant. The reason is that married people choose to remain in their parents' homes so that the number of occupants in one house increases and solidifies. Residential density also occurs in Sweden, so people try to save in the use of clean water.[9]

The study supports the argument that the effect of residential density on clean water with a value of 88.8% is very vulnerable to clean water. The results of research with SEM that occupancy density has a significant relationship to the vulnerability of clean water. The vulnerability of clean water is a problem. As many as 1.2 million deaths occur due to unsafe water. It is estimated that by 2025, half of the world's population will experience water shortages.[10]

Conclusions

It is concluded that community behavior and occupancy density are the main factors for the vulnerability of clean water on the small islands of Spermonde. Adaptation behavior with water vulnerability such as water storage and saving needs to be improved.

Conflicts of interest

The authors declare no conflict of interest.

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